HSPF in Watershed Planning in Minnesota

Andrea Plevan and Jennifer Olson
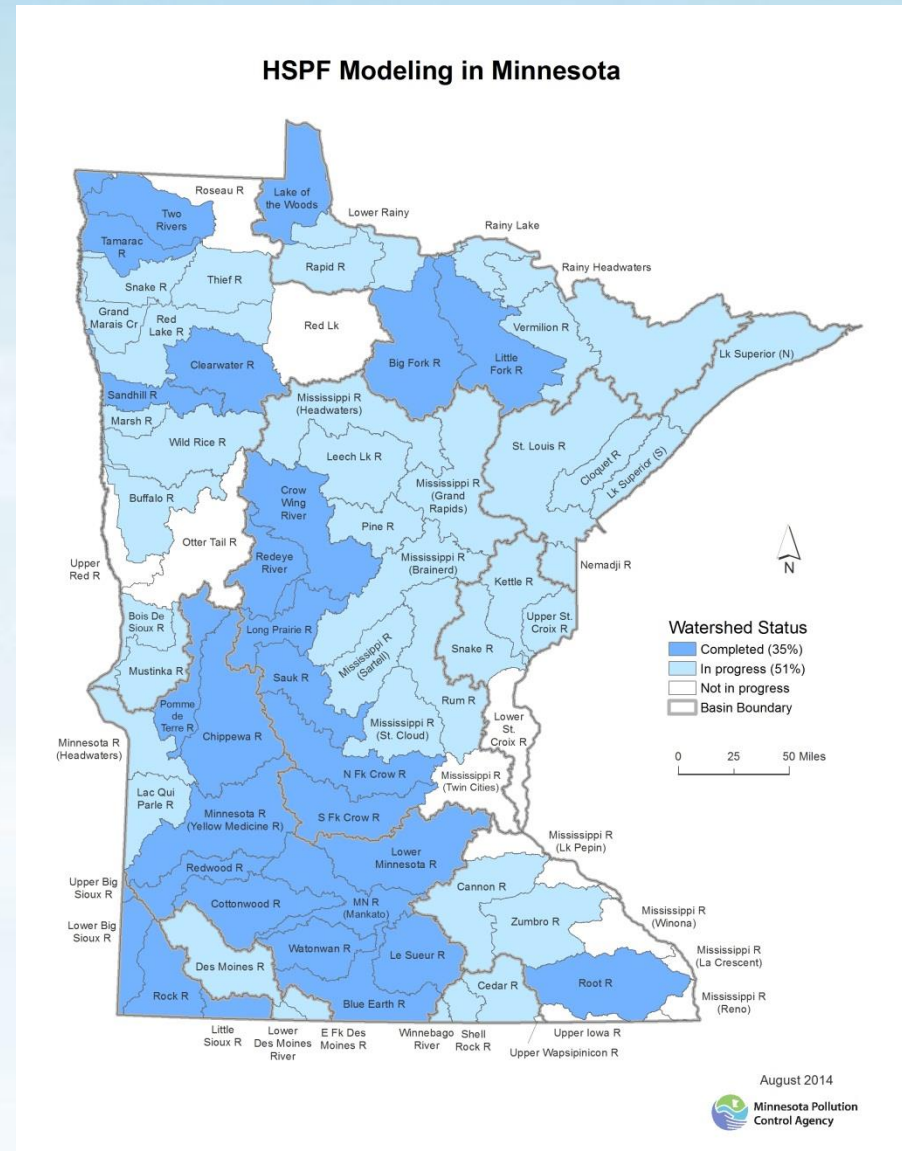
October 29, 2014

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Statewide Watershed Modeling

▶ MPCA-led effort to develop watershed models on a major watershed basis

▶ Models can be used to support:

- TMDL and WRAPS
- Permit evaluation
- Land use planning/scenarios
- Pollutant trading
- Other modeling efforts such as lake modeling
- LGU: watershed planning, BMP evaluation, etc.

HSPF Modeling in Minnesota

Watershed Status
- Completed (35%)
- In progress (51%)
- Not in progress
- Basin Boundary

0 25 50 Miles

August 2014

Minnesota Pollution Control Agency

Overall Modeling Approach
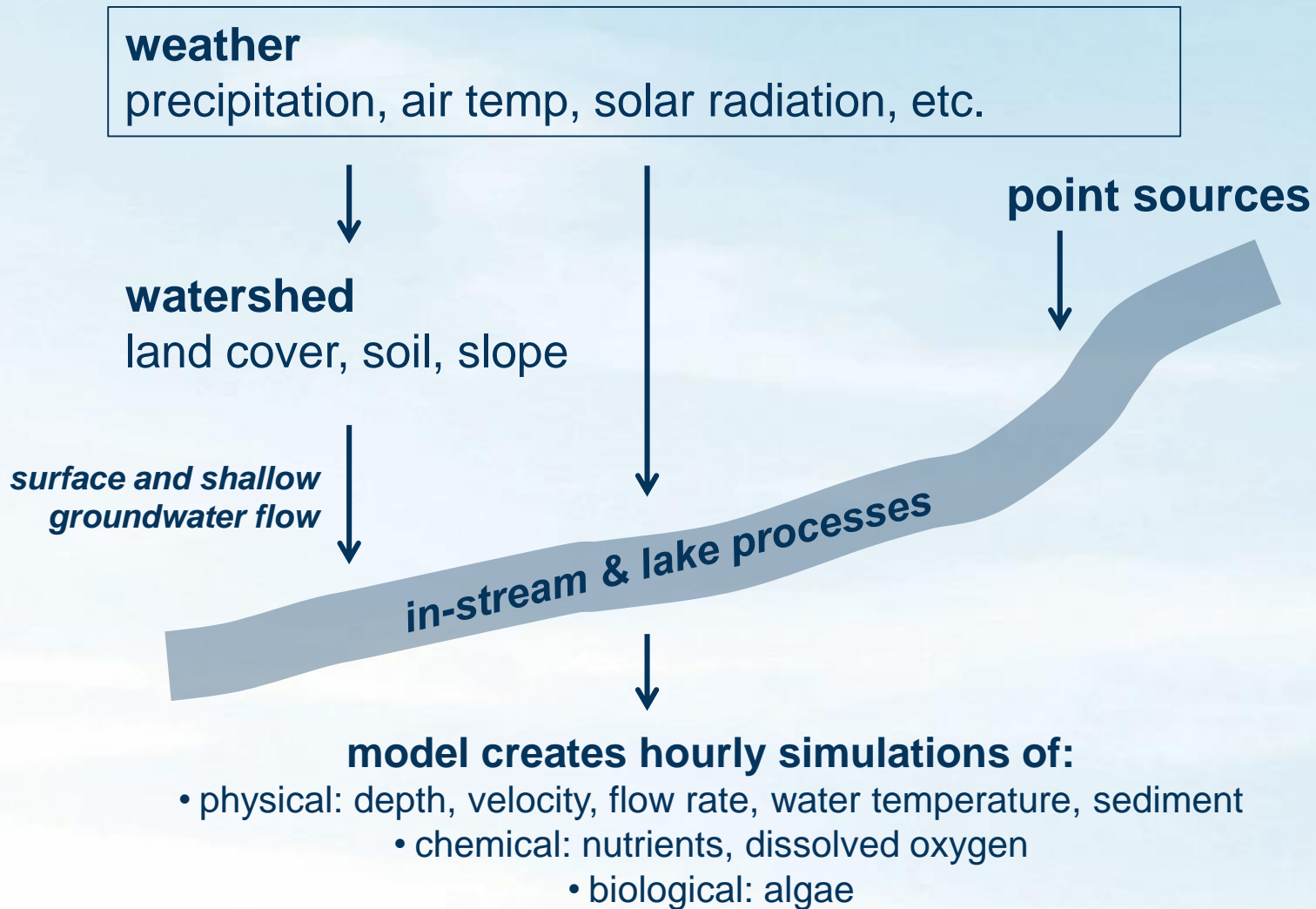
► Create a computer simulation model of flow and water quality in each major watershed

► Why not just observe what is happening?

- Build and test our understanding of the connection between causes and responses
- Provide a basis for evaluating things we can't observe, such as responses to future changes in watershed conditions
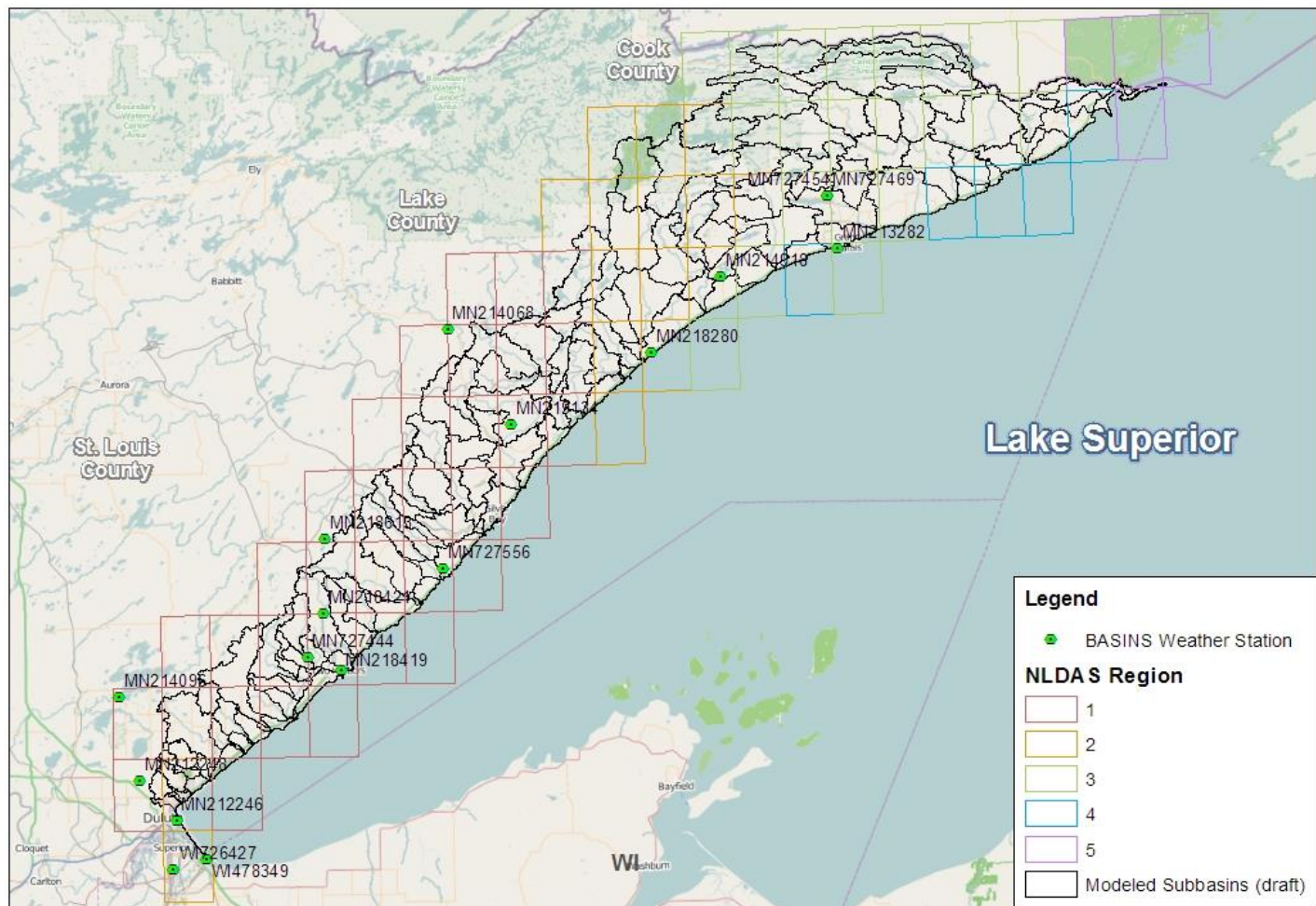

Amity Creek

Little Chippewa River

The HSPF Modeling Framework

► HSPF = Hydrological Simulation Program–FORTRAN

► Well-established and widely applied comprehensive dynamic watershed simulation model

► Supported by USEPA and USGS

► Approved for use by FEMA

► Applied throughout Minnesota

► Hourly time step simulations of flow, water temperature, dissolved oxygen, sediment, nutrients, and other pollutants

HSPF Model Structure

weather
precipitation, air temp, solar radiation, etc.

point sources

watershed
land cover, soil, slope

*surface and shallow
groundwater flow*

in-stream & lake processes

model creates hourly simulations of:
• physical: depth, velocity, flow rate, water temperature, sediment
• chemical: nutrients, dissolved oxygen
• biological: algae

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Model Setup—Meteorology
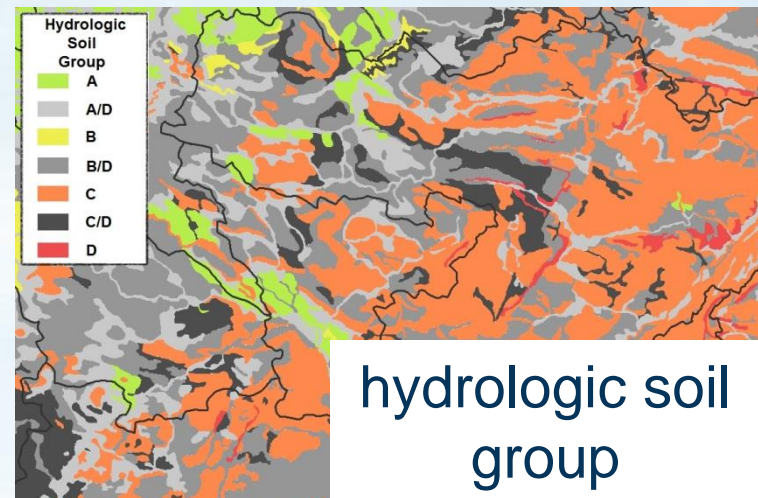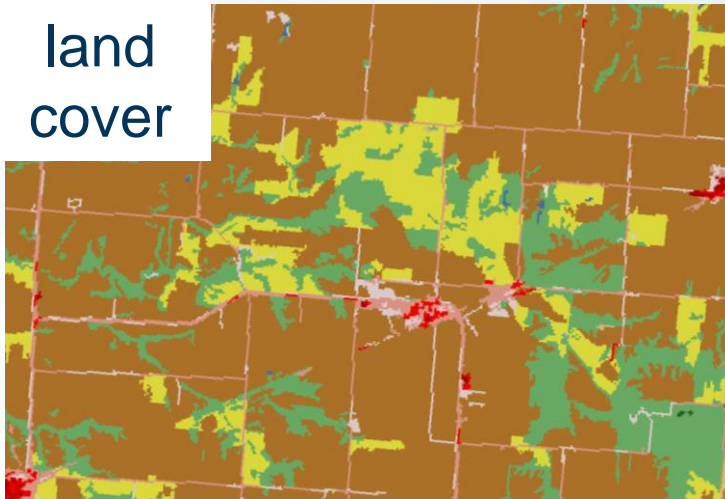

Hourly precipitation, temperature, radiation, dew point, wind, cloud cover
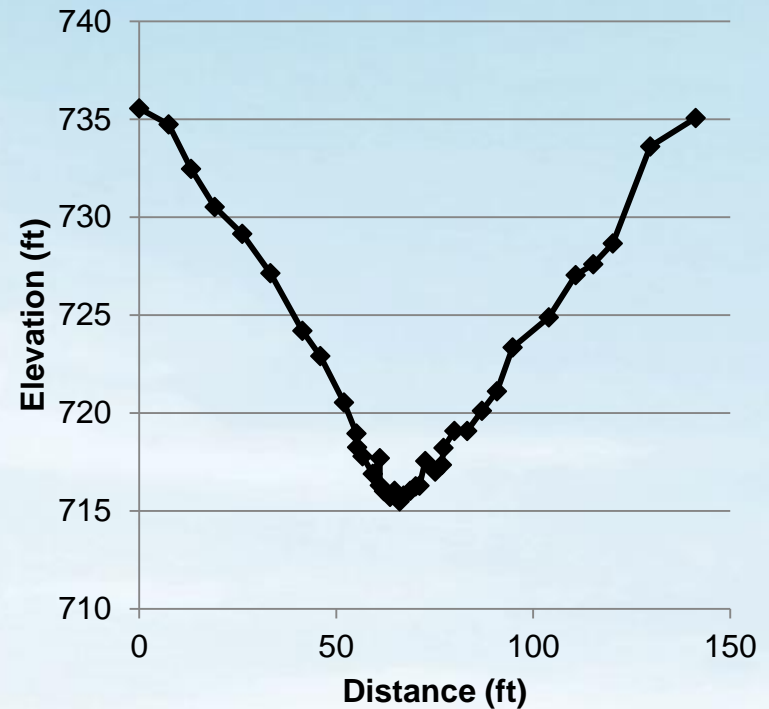
Model Setup—GIS Intensive
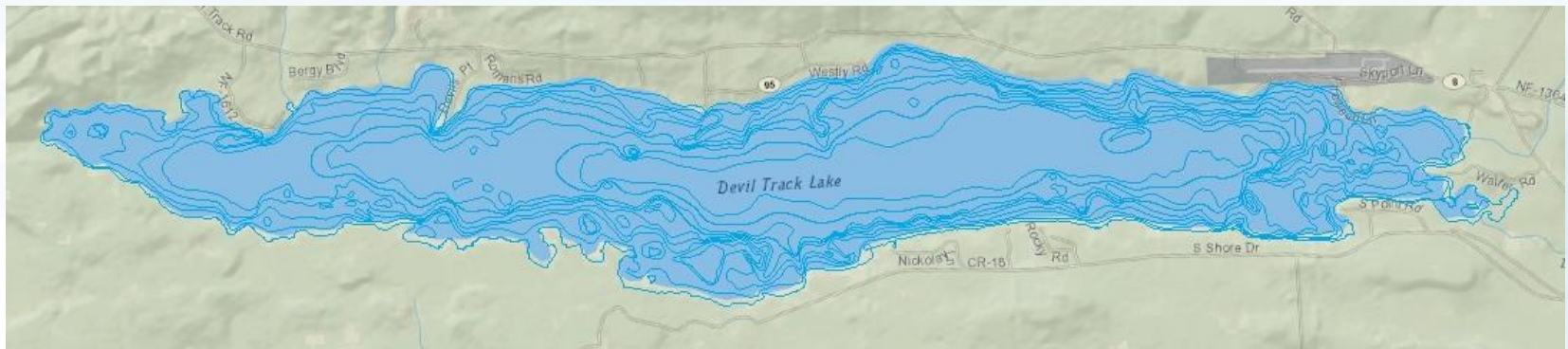

drainage network

land cover

hydrologic soil group

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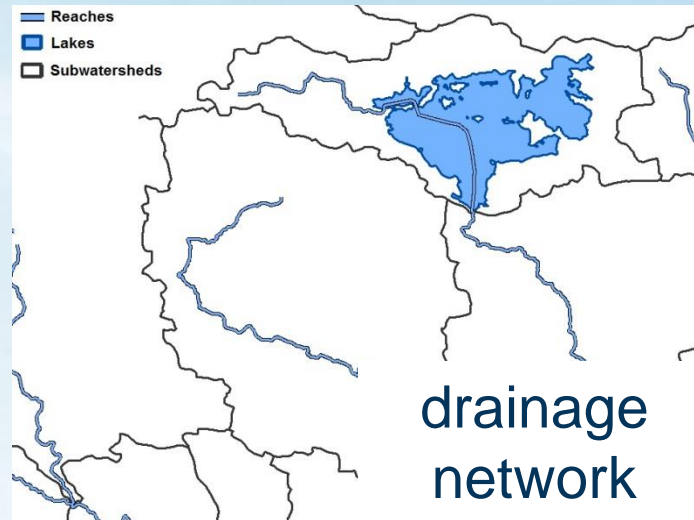
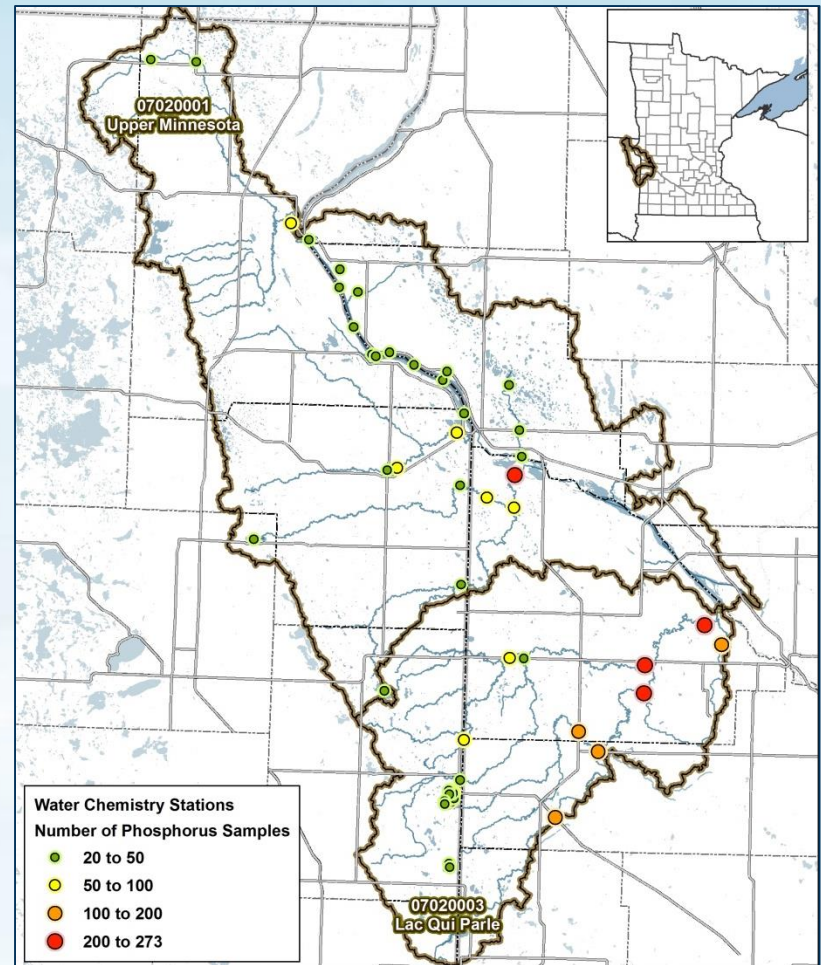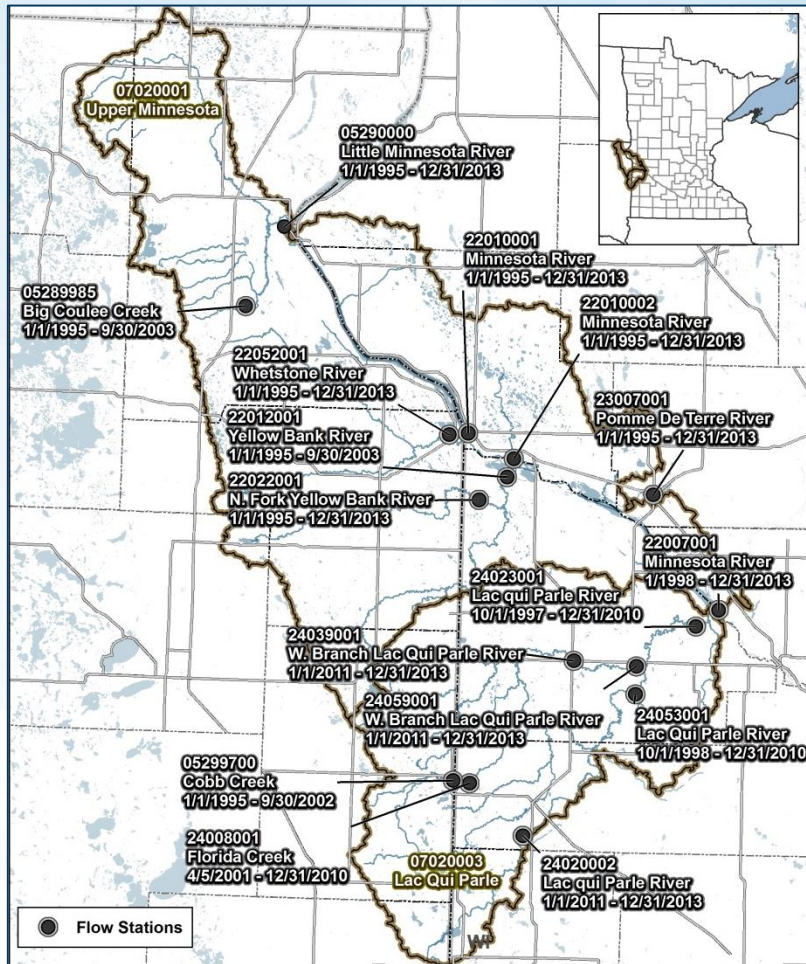# Model Setup–Channel Geometry

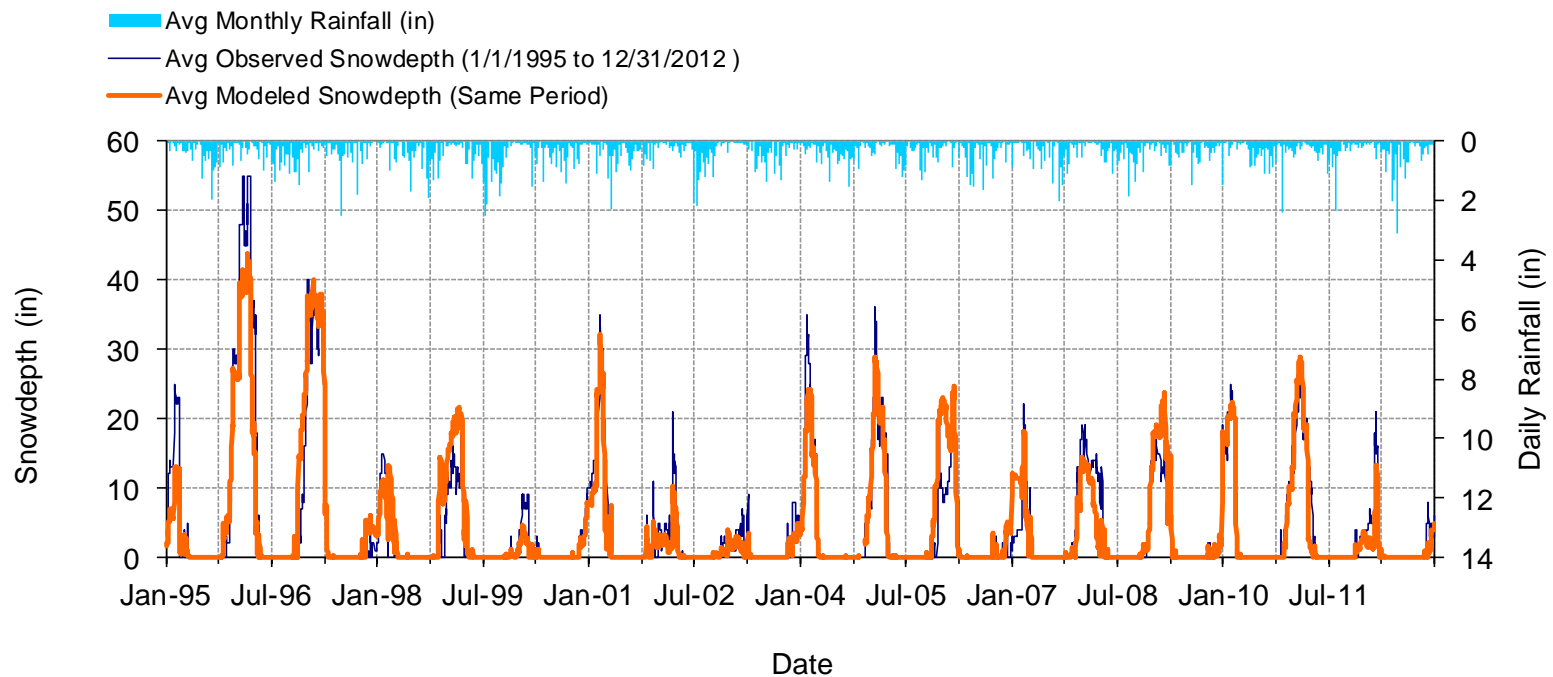► Channel cross-sections

► Lake bathymetry

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Calibration Data: Flow and Water Quality

Model Calibration: Hydrology and Water Quality

► Calibrate model to reproduce observed data

► Conduct separate corroboration test to validate model performance on a separate set of data

Model Outputs

► Model outputs at hourly interval

- Physical: depth, velocity, flow rate, water temperature, sediment
- Chemical: nutrients, DO
- Biological: algae

► Model outputs at each stream reach

Date	Flow (cfs)	DO (mg/L)
8/3/09 5:00	3.1	10.0
8/3/09 6:00	3.1	10.0
8/3/09 7:00	3.2	10.1
8/3/09 8:00	3.2	10.1
8/3/09 9:00	3.3	10.2
8/3/09 10:00	3.2	10.2
8/3/09 11:00	3.3	10.2
8/3/09 12:00	3.1	10.3
8/3/09 13:00	3.1	10.2
8/3/09 14:00	3.2	10.2
8/3/09 15:00	3.2	10.3
8/3/09 16:00	3.3	10.3
8/3/09 17:00	3.3	10.4
8/3/09 18:00	3.3	10.4
8/3/09 19:00	3.3	10.4
8/3/09 20:00	3.4	10.5
8/3/09 21:00	3.4	10.4

Model Outputs

Hourly

Date	Flow (cfs)	DO (mg/L)
8/3/09 5:00	3.1	10.0
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8/3/09 19:00	3.3	10.4
8/3/09 20:00	3.4	10.5
8/3/09 21:00	3.4	10.4

Daily (average, min, max, etc.)

Date	DO Daily Min (mg/L)
8/1/2009	10.0
8/2/2009	9.9
8/3/2009	9.9
8/4/2009	9.4
8/5/2009	9.3
8/6/2009	9.0
8/7/2009	8.8
8/8/2009	8.5
8/9/2009	8.3
8/10/2009	7.9

Annual

Year	Annual TP Load (lb)
2009	188
2010	245
2011	611
2012	387

Other time frames…

Analyses, graphs, maps
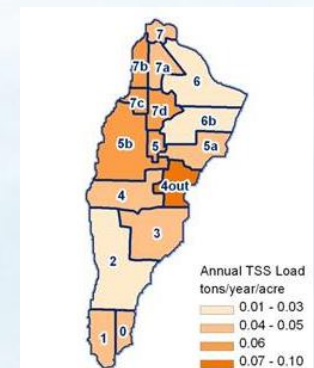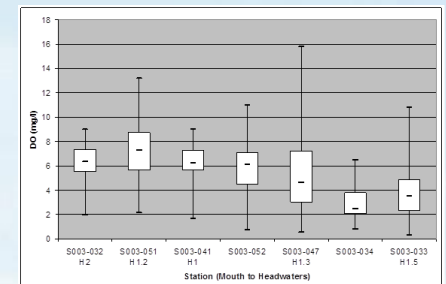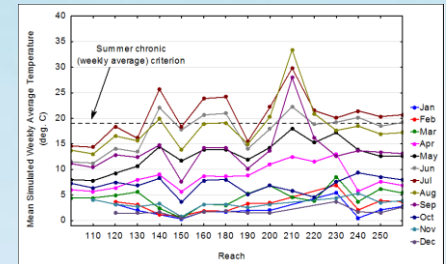
Pollutant Source Assessment

By subwatershed

Annual TSS Load
tons/year/acre
- 0.01 - 0.03
- 0.04 - 0.05
- 0.06
- 0.07 - 0.10

By land cover

- Forest
- Agriculture
- Developed
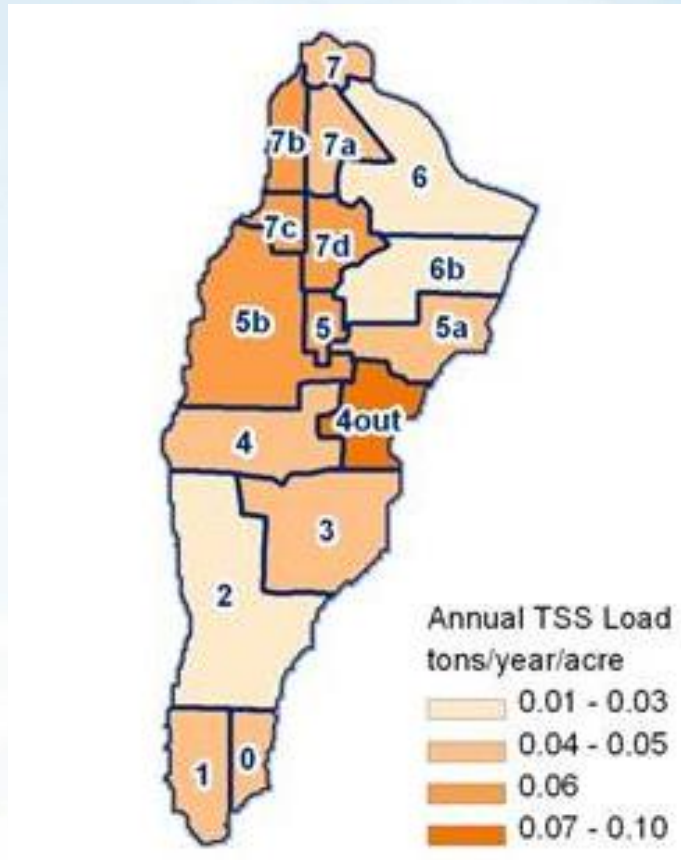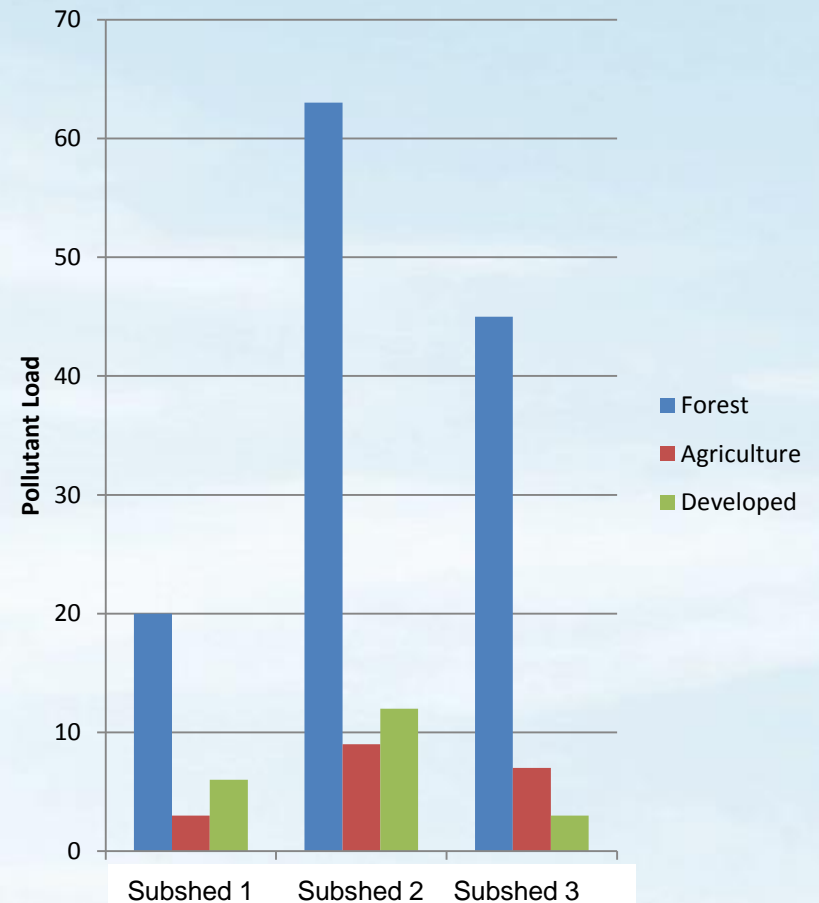
Protection vs. Restoration

► Restoration

- Identify causes of impairment
- Model ability of potential management practices to meet water quality reduction goals

► Protection

- Identify threats to water quality
- Model ability of potential management approaches, regulations, zoning, ordinances, etc. to prevent degradation
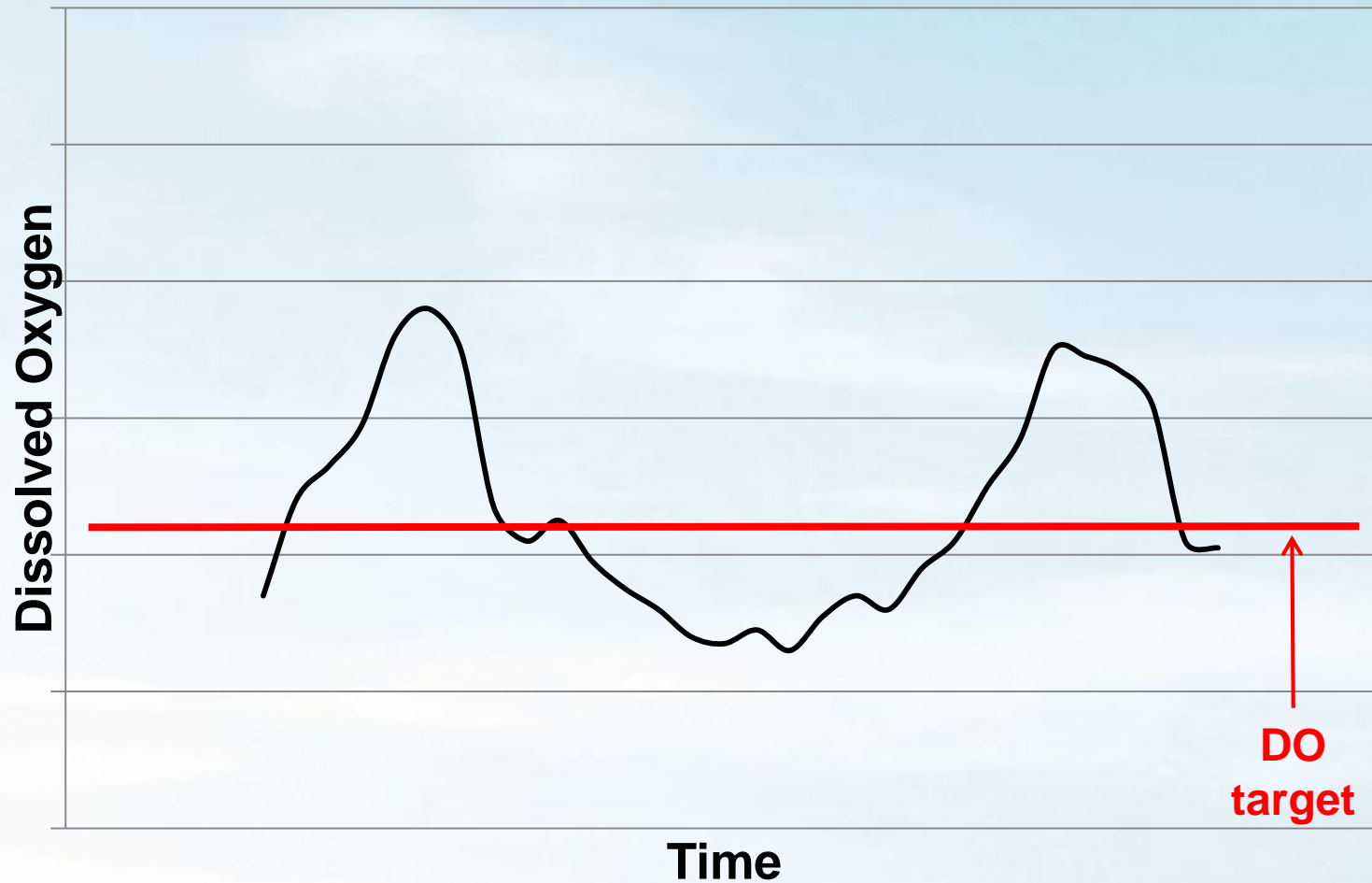

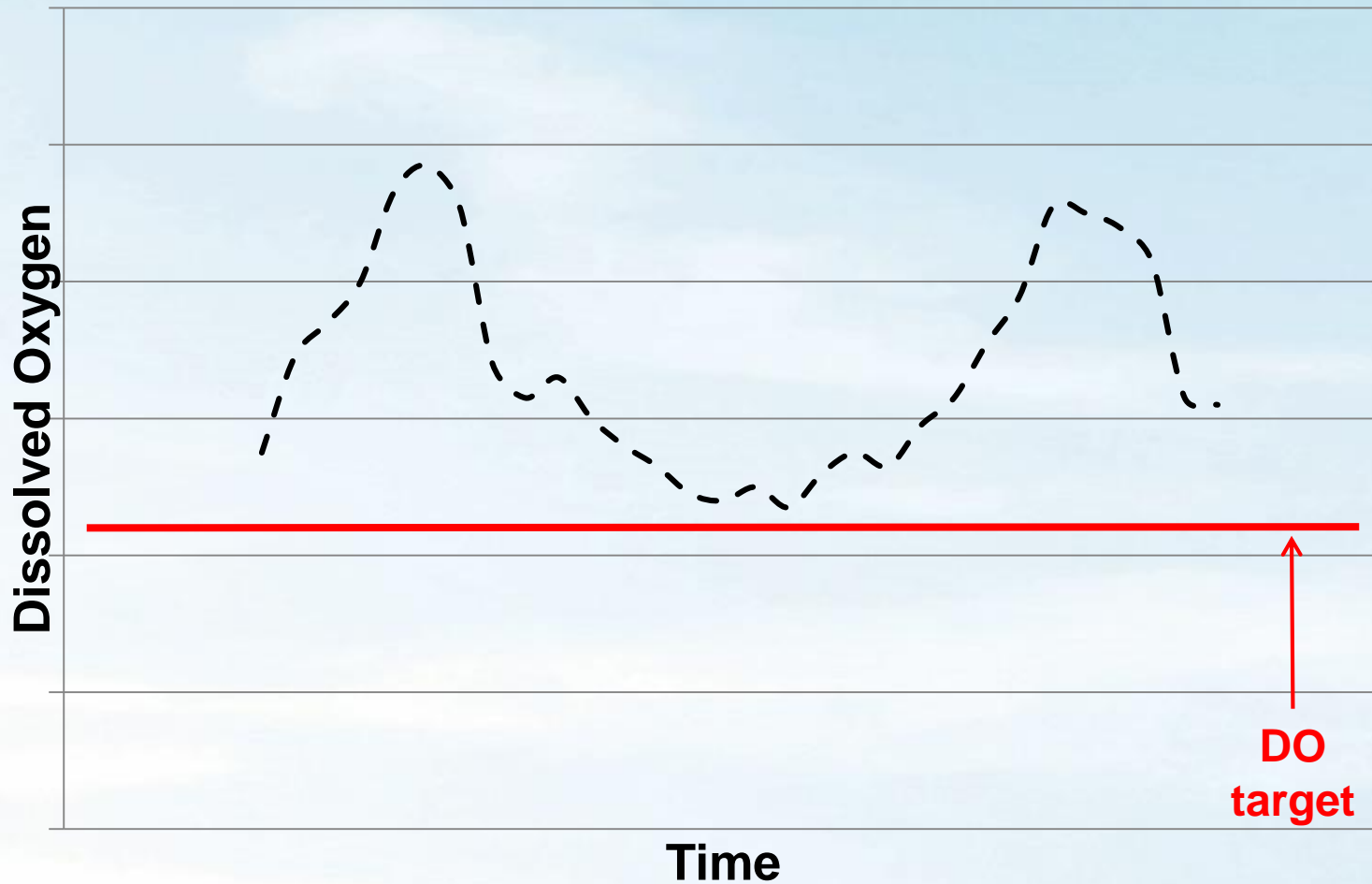Mississippi Backwaters, MPCA

Pelican Lake

Stressor Identification: Restoration

Example: evaluate frequency and duration of low dissolved oxygen

Risk Identification: Protection

Example: evaluate frequency and duration of low dissolved oxygen

Concept of a Model Scenario

weather
precipitation, air temp, solar radiation, etc.

point sources

watershed
land cover, soil, slope

*surface and shallow
groundwater flow*

in-stream & lake processes

model creates hourly simulations of:
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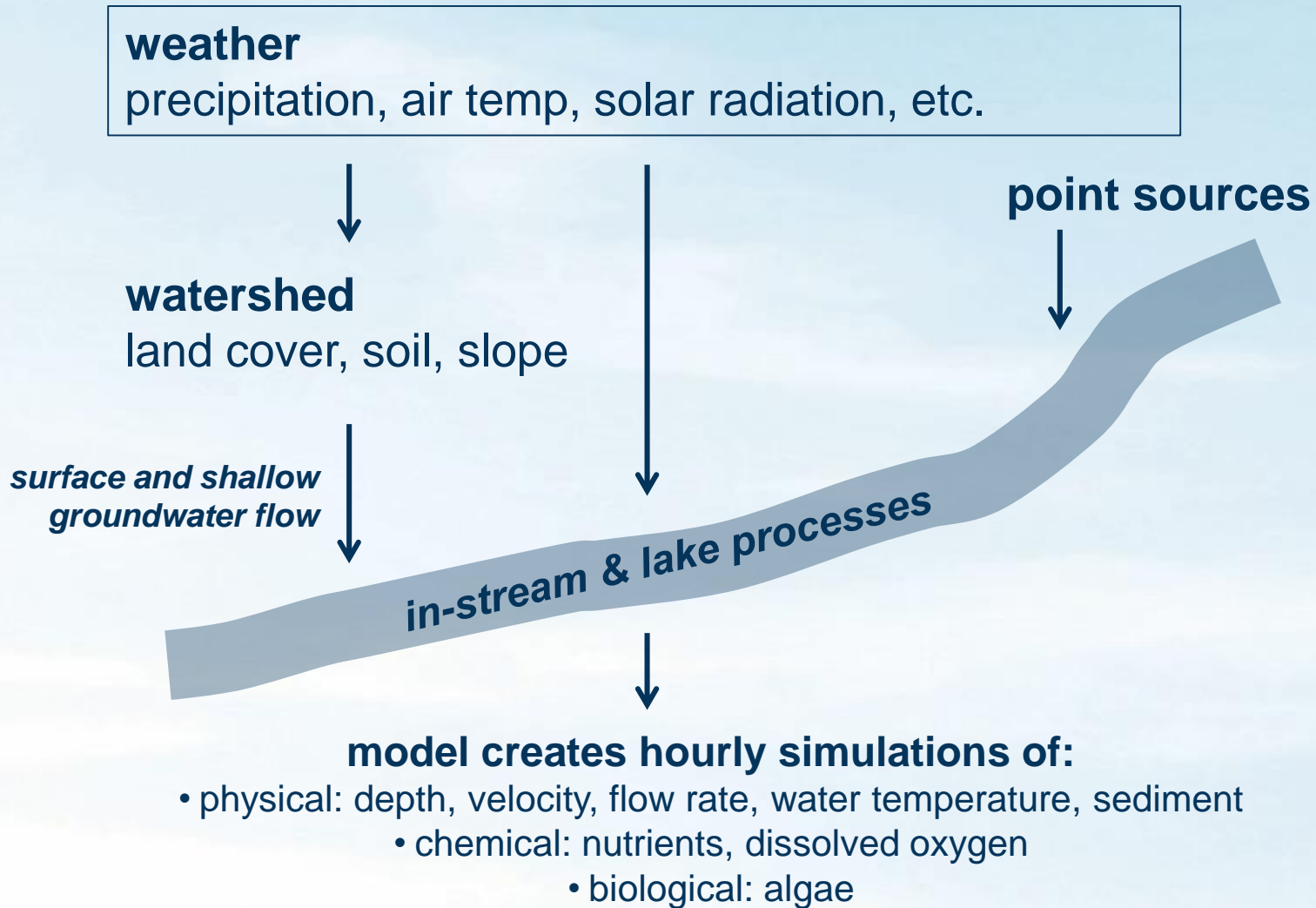
Management Scenarios: Restoration

► Hypothetical scenarios: proposed riparian buffer restoration, water and sediment control basins

- Watershed-wide evaluation
- Not a field scale model

► What if…?

- What if we implement buffers and basins across the entire watershed?
- If that's not feasible, what if we implement across half of the watershed?
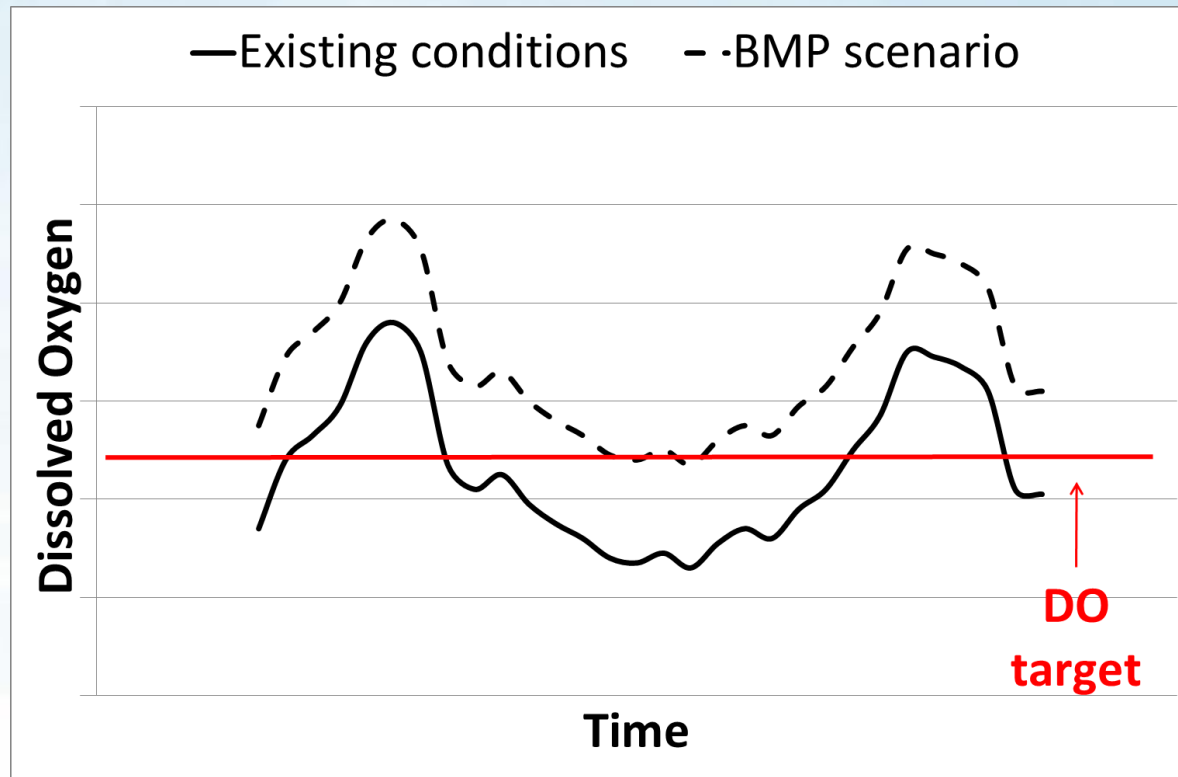- If that's not enough to reach our goal, what other BMPs can we put in?
- Etc.

Example results

| Scenario	TSS (T/yr)
Base	823
25% of ag	717
50% of ag	602
100% of ag	387

Management Scenarios: Restoration

► Hypothetical scenarios

- What about impact on dissolved oxygen?
- Hourly DO concentrations

Management Scenarios: Protection

► Hypothetical scenarios

- Proposed residential developments / urban growth
- Scenario with mitigation (A): Proposed developments with protection measures (e.g., zoning, ordinances)
- Scenario with mitigation (B): Add in voluntary BMPs

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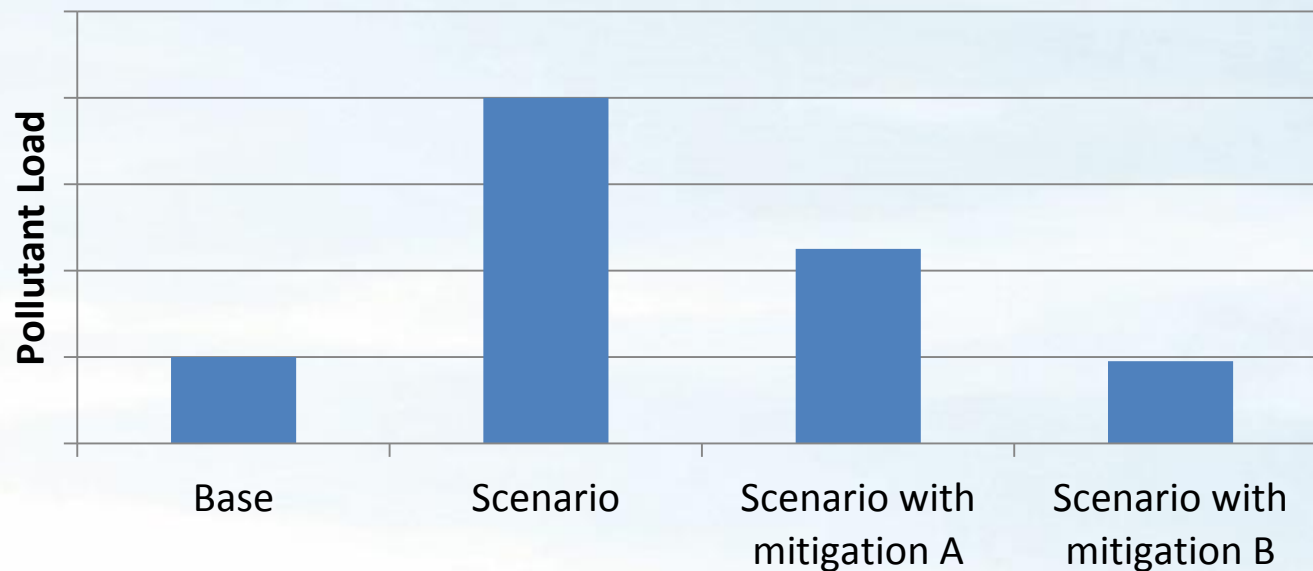
Management Scenarios: Protection

► Hypothetical scenarios

- New point source discharge permit application
- Evaluate impact immediately downstream and at the point the stream flows into another downstream water body (e.g., an impaired lake)
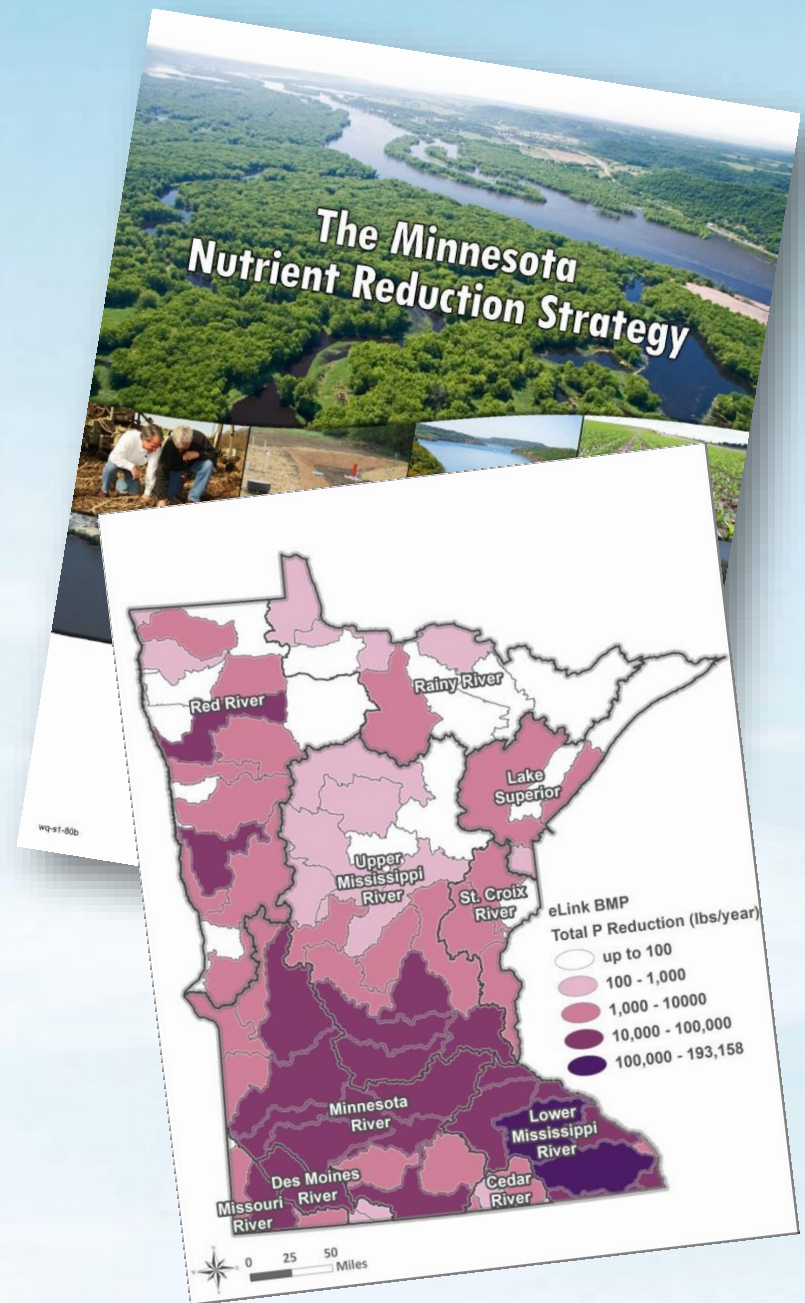

Downstream impacts

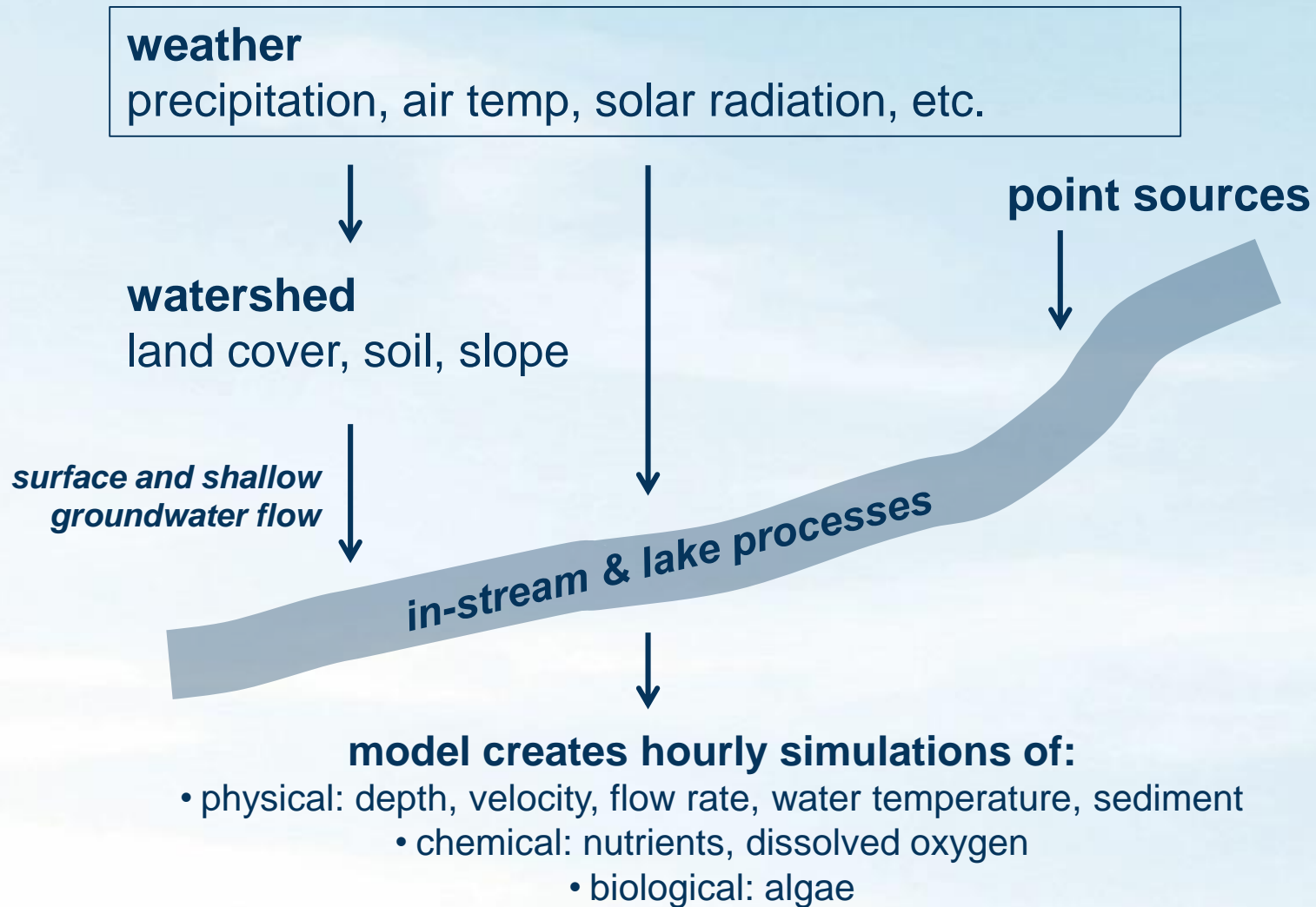# Measureable Goals

► Model scenarios to quantify load reductions

► Model scenarios for grant applications

► Load reductions can be reported on HUC12, HUC8, etc. level to compare with statewide goals (e.g., Nutrient Reduction Strategy)

The Minnesota Nutrient Reduction Strategy

eLink BMP
Total P Reduction (lbs/year)
- up to 100
- 100 - 1,000
- 1,000 - 10000
- 10,000 - 100,000
- 100,000 - 193,158

HSPF Components for Use in Planning

weather
precipitation, air temp, solar radiation, etc.

point sources

watershed
land cover, soil, slope

surface and shallow groundwater flow

in-stream & lake processes

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Questions/Comments?

Thank You!

andrea.plevan@tetratech.com